

Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder, Polypropylene Fibers And Superplasticizers

Shirsath Samiksha¹, Dr. P. K. Kolase^{2*}

¹PG Student, Department of Civil Engineering, Pravara Rural Engineering College, Loni, Maharashtra, India
shirsathsamiksha7@gmail.com

^{2*} Associate Professor, Head of Department, Department of Civil Engineering, Pravara Rural Engineering College, Loni, Maharashtra, India pramodkolase@gmail.com

ABSTRACT:

Returned concrete generated from construction sites represents a major source of material waste and environmental concern in the construction industry. This study investigates the feasibility of blending returned concrete with fresh concrete by incorporating varying dosages of metakaolin (MK) powder, polypropylene (PP) fibers, and superplasticizers for returned concrete aged from 0 to 5 hours. The objective was to evaluate the influence of these materials on the fresh, mechanical, and durability properties of blended concrete and to identify an optimum combination capable of mitigating the adverse effects of concrete ageing. An experimental program was conducted using metakaolin powder as a partial cement replacement at levels ranging from 5% to 20%, polypropylene fibers from 0.25% to 0.75%, and superplasticizers from 1% to 3%. Hardened concrete performance was evaluated through compressive strength. The results revealed that increasing the ageing period of returned concrete reduced workability and adversely affected strength and durability characteristics. However, the incorporation of metakaolin significantly enhanced compressive strength due to its pozzolanic reactivity and pore-refining effect. Polypropylene fibers improved crack resistance, toughness, and post-cracking behavior, while superplasticizers effectively restored workability and improved the dispersion of cementitious particles. The combined use of MK powder, PP fibers, and superplasticizers was found to compensate for the negative effects of ageing and produced blended concrete with satisfactory engineering performance even at higher ageing durations. The findings contribute to reducing concrete waste, conserving natural resources, lowering production costs, and promoting sustainable construction practices.

Keywords- Returned concrete, fresh concrete, Blending, Metakaolin Powder, Polypropylene Fibers, superplasticizers, compressive strength.

How to cite this article: Shirsath S, Kolase PK. Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder, Polypropylene Fibers And Superplasticizers. Int J Drug Deliv Technol. 2026;16(6): 190-206. DOI: 10.25258/ijddt.16.6.27

1. INTRODUCTION:

Concrete is recognized as one of the most widely used materials, indispensably contributing to the civil engineering sector. The primary component of concrete is cement. The global production of Ordinary Portland Cement (OPC) is nearly four billion tons per year. The production of cement, however, has raised significant environmental concerns, particularly due to its contribution to greenhouse gas emissions. In fact, it contributes to the emission of carbon dioxide (CO₂) through the combustion of fossil fuels and calcining of limestone. Globally, the production of one tone of OPC generates around 0.95 tons of CO₂, with the total CO₂ released by manufacturing OPC estimated to be between 5% and 8% of the global anthropogenic CO₂ emissions into the atmosphere. Returned fresh mix concrete (RFC) is a problem with both economic and environmental impacts. Among the most common procedures are dumping concrete in landfill, recycling it, using the aggregate, and using it to produce concrete blocks. Waste concrete is a problem for the concrete manufacturing industry. The term used to define unused concrete that is returned to a facility inside

a truck is leftover, and of this, 60% goes directly to a dump, while only 40% is used to produce other concrete blocks or recycled products. Ready-mixed concrete, on the other hand, is the fresh concrete produced for delivery to purchasers. The amount of waste concrete varies between 1% and 13%. Part of this waste belongs to concrete returns to a plant from job sites, with around 2% to 10% of concrete returning to a facility as left-over. Moreover, handling and disposing of returned concrete is expensive. Sometimes, companies need to transport it to landfills or provide space for storage.

The main indicator for the quality of the concrete mix, both in the short and long term and at the same time, reduce the needed OPC content in concrete and leads to a decrease in the dependency of OPC in the concrete industry which is responsible for about 5% of the CO₂ emissions. A main indicator for quality control in reinforced concrete structures is concrete's compressive strength, which is an essential element in the design of concrete structures. However, several factors, including the age of the concrete, curing environment, mix proportions, and material properties, influence compressive strength. While cement is the

*Author for Correspondence: pramodkolase@gmail.com

key ingredient in concrete and has shaped much of our built environment. Many mineral additives, such as Silica Fume (SF), Metakaolin (MK), Fly Ash (FA), and Blast Furnace Slag(BFS), have been used as a replacement for Ordinary Portland Cement(OPC) during the last five decades. These mineral admixtures improve the mechanical and durability of concrete, including the concrete compressive strength.

Metakaolin is produced by calcining kaolin at high temperatures and typically contains 40–45 % aluminum oxide (Al_2O_3) and 50–55 % silicon dioxide (SiO_2). The byproduct of cement hydration, CH, negatively impacts the mechanical and durability properties of concrete and does not significantly enhance the desired strength. The SiO_2 and Al_2O_3 present in MK can react with CH in the presence of water to form C-S-H, calcium aluminates hydrates (CAH), and calcium aluminosilicate hydrates (CASH). The dehydration of kaolinite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) at an adequate temperature (600-900°C) can produce metakaolin, an anhydrous aluminum silicate ($Al_2O_3 \cdot 2SiO_2$) that has a particular silicon source and is hence a viable material that may replace cement.

Also, concrete is an example of a brittle material and has poor performance in ductility. The strength and durability of the concrete is significantly influenced by properties of the fibers, including the fiber type, fiber length, aspect ratio, surface texture, and tensile strength. In general, conventional concrete has more resistance in compression and less resistance against tension, fatigue, and toughness. Fibers are used in enhancing the fatigue and toughness performance of the concrete. The present research work discusses the production of economical and cost effective concrete after adding Polypropylene Fibers (PPF) to reduce harmful effects of untreated waste plastic on environment and to improve the strength properties, with addition of Metakaolin as a supplementary cementitious material. All researchers reported that adding fiber from waste materials into concrete mixes reduces the workability of the concrete. However, most researchers state that adding fiber can increase concrete's mechanical strength, especially its tensile strength. However, a researcher also reports a decrease in concrete's compressive and tensile strength due to the addition of waste fiber, especially when utilizing waste metal materials. The addition of plastic waste fibers into the concrete mixtures reduced the workability of the concrete, slightly increased its compressive strength, significantly increased its tensile strength, and reduced its thermal conductivity. The addition of Polypropylene fiber to the concrete mixture even reported as possible to be carried out up to 3% based on the volumetric ratio. The current study discusses the combined effect of pozzolanic materials (cement and Metakaolin) and Polypropylene fibers on fresh and hardened properties of concrete, also discusses these effects when freshly prepared concrete blended with site

leftover concrete for the duration of 1 hour, 2 hours, 3 hours, 4 hours and 5 hours. MK is incorporated at 5 %, 10 %, 15% and 20 % as a partial replacement to cement by weight. The test results showed that the presence of Polypropylene fiber in the mix decreased its flowability. However, when added up to 0.75%, the mixes still meet the flowability requirements of fresh-state concrete. In addition, investigators have suggested using some stabilizing additives to help returned concrete stay fresh for a longer time and allow for reusing it, with the addition of a super-stabilizer based on concrete hydration control. This stabilizer turns the concrete into a plastic concrete, which lasts up to 72 hrs.

2. LITERATURE REVIEWS:

[1] Mostafa M. et. al (2025):

This research investigates the effects of using metakaolin powder, prepared in a concrete mix, on the workability and compressive strength of concrete containing MK in different ratios. MK was incorporated at 5 %, 10 %, and 20 % as either a partial replacement or additive to cement by weight. The compressive strength increased by 13%, 11%, and — 5% at 7, 28, and 365 days, respectively, with no MK and the use of MW.

[2] Bhuriya Dayal Dinabhai, et. al. (2025):

This research investigates the use of recycled polyethylene terephthalate (PET) fibers and copper slag as partial replacements for conventional concrete ingredients. The study focuses on the impact of these additions on the fresh and hardened properties of concrete. Experimental results indicate that the combination of 'O' shaped PET fibers and 60% copper slag significantly enhances the compressive strength, split tensile strength, and flexural strength by 25.85%, 26.39%, and 28.09%, respectively.

[3] Syed Nasir Abbas^a, et. al. (2024):

In this study, high-density polyethylene plastic is incorporated in aggregate form, as a partial substitute for natural coarse aggregates (NCA) at volumetric ratios of 10%, 30%, and 50%. Various strength enhancement techniques, including the addition of macro synthetic fibers (MSF), steel fibers (SF), and substituting 20 % of cement with silica fume, were employed. The results indicated that workability of concrete is improved with an increase in the content of HDPE coarse aggregates (HCA). The significance of this research lies in the utilization of HDPE waste materials in concrete by simultaneous usage of different fibers.

[4] Slamet Widodo, et. al (2023):

This study aims to utilize fly ash and waste PET

bottles for producing more sustainable self-compacting concrete with better mechanical strength. Fly ash is utilized as a supplementary cement material and waste PET bottles as fiber reinforcement to improve its flexural strength and achieve the targeted compressive strength. The two variants are added with PET fiber based on the volume fractions of 0%, 0.25%, 0.50%, and 0.75%.

[5] Aktham H. Alania, et. al. (2022):

The effects of adding recycled waste plastic bottles in the form Polyethylene Terephthalate (PET) fiber on the flexural and tensile behavior of Ultra- High Performance PET Fiber Reinforced Green Concrete containing different volumes of Ultra-fine palm oil fuel ash and Silica Fume have been investigated. The results showed that the addition of PET fibers modulates the stiff and brittle behavior of Ultra High-Performance Green Concrete (UHPGC).

[6] Yousef R. Alharbi^a, et. al. (2021):

This paper studies the impact of using metakaoline (MK) as an available alternative pozzolanas to replace silica fume(SF) in the development of Reactive Powder Concrete (RPC) in Egypt. he results showed that the blended SF and MK enhanced the strength and the durability of the RPC.

[7] Negasi N. et. al. (2019):

In this study, the authors investigated the behavior of various proportions of RFC mixed with ready-mix plain and retarded concrete. The authors also studied the influence of aging by producing specimens after one, two, three, and four hours. In addition, the researchers investigated controlled and uncontrolled environments by mixing the samples both indoors and outdoors. Workability, setting time, and compressive strength of cylindrical mixed specimens was then evaluated.

[8] Reza Noroozi^a, et. al. (2019):

To enhance the performance of RCCP, the mixtures were also modified by using pozzolanic Metakaolin (MK) as a partial substitute for cement and adding steel fibers obtained from the recycling of worn vehicle tyres. The optimal mix design obtained from the statistical model involves replacing 25 vol% of fine aggregate with PET, replacing 20 wt% of cement with MK powder, and adding 1.9 wt% SRSF to the mixture.

[9] Khaled Marar and Özgür Eren (2011):

This paper investigates the effects of cement content

and water/cement ratio on workable fresh concrete properties with slump changing between 90 to 110 mm, and determines the relations among fresh concrete properties such as slump, compacting factor, Vee Bee, unit weight and setting times of mortar with temperature history. It was observed that increasing the cement content causes increase in the slump, K- slump, compacting factor and fresh concrete unit weight, and reduces Vee Bee time.

3. EXPERIMENTAL STUDY:

3.1 MATERIALS AND METHODS:

All other raw materials used in the laboratory and in the production conditions by the RMC (cement, additives, and regular aggregates) were kept constant in the study. In the specimens, cement is partially replaced with MK powder from 5% to 20%. And polypropylene fibers are added with 0.25%, 0.50% and 0.75% by volume of concrete and super plasticizers are added with 1%, 2% and 3%.

1. Cement:

In this study, OPC grade 53 was used for preparing concrete cubes. The specific gravity was 3.15. 90-95% of OPC 53-grade particles are able to pass through a 45 µm finer sieve, which emphasises its exceptional fineness. It is 225 m²/kg.

2. Fine Aggregates:

The High Quality Natural Sand which is required for this project work is source from riverbeds. The composition of this High-quality natural sand is clean and free from impurities like silt, clay, shells, and organic matter, as these can reduce the strength and durability of the concrete. These sand particles having a smooth, rounded shape with specific gravity 2.45. This texture contributes to good workability, making the concrete mix easier to apply and providing smooth finishes for applications like plastering. This natural sand with particles smaller than 4.75 mm that pass through a 4.75 mm sieve.

3. Coarse Aggregates:

Angular and rough-textured coarse aggregates of size 200mm with the specific gravity 2.67 are used for the project work. These types of aggregates generally provide better strength and durability due to enhanced interlocking with the cement matrix, because proper grading (particle size distribution) is vital for achieving optimal density, which impacts the strength and workability of the concrete mix. These selected aggregates having low water absorption property, because the aggregates with low water absorption help maintain the intended water-cement ratio, which is crucial for controlling concrete strength.

Properties	FA	CA
Fineness Modulus	2.34	4.73

Specific Gravity	2.62	2.68
Absorption (%)	1.52	0.81
Bulk Density (kg/m ³)	1785	1634

Table No.1 :Physical properties of aggregate.

4. Metakaolin Powder:

Metakaolin is often white, which lightens the color of concrete for architectural applications. Its fine particles fill voids and improve the mix's rheology, resulting in a smoother, less sticky, and more cohesive mix that is easier to finish and less prone to efflorescence. It densifies the concrete's microstructure, reducing permeability to water, chlorides, and sulfates. This improves resistance to chemical attacks, freeze-thaw cycles, and general degradation, making it ideal for infrastructure projects like bridges and marine structures. Optimal cement replacement levels typically range from 10% to 15% by weight, leading to increased compressive and flexural strength. MK tends to reduce the workability (slump) of the fresh mix due to its high surface area and water absorption properties. The specific Gravity of MK is 2.34.

5. Polypropylene Fiber:

These are synthetic reinforcement fibers of size 12mm added to concrete to improve its performance, primarily by increasing crack resistance, toughness, and durability, not for primary structural support. They are effective against shrinkage and cracking, enhance impact and abrasion resistance, and prevent spalling. PP fibers are lightweight, corrosion-resistant, and do not break down in the alkaline environment of concrete, unlike some other synthetic fibers like fiberglass. Optimal fiber content is often found around 0.5% to 1.0% by volume; higher percentages can lead to fiber clumping and reduced workability. They provide secondary reinforcement to the concrete, helping to prevent the formation of micro-cracks caused by plastic shrinkage during curing.

2.6 Super plasticizers:

Returned concrete aggregates differ from natural aggregates, primarily due to adhered old mortar, which results in higher water absorption and a more complex, rougher surface structure. This necessitates a super plasticizer with strong dispersion capabilities and good compatibility to manage the workability and strength properties effectively. For blending returned concrete with fresh concrete, **Poly Carboxylate Ether (PCE)** based super plasticizers are the most effective and widely used.

PCEs work through a combination of electrostatic repulsion and a strong steric hindrance effect due to their comb-like molecular structure with long side chains. This mechanism is highly effective at dispersing the diverse and irregular particles found in recycled aggregate mixes, leading to high flowability

and reduced water content without segregation.

2.7 Water:

Generally, water that is fit for drinking (potable) is considered suitable for concrete. It must be reasonably clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials, or other substances that could be detrimental to the concrete or cause corrosion of reinforcing steel.

CONCRETE SPECIMEN PREPARATIONS:

There are 6 concrete mixes prepared for this research work. The concrete cubes of size 150mm × 150mm × 150mm size were cast with varying percentages of Metakaolin Powder and Polypropylene fibers. The concrete cubes are prepared as the blending of site leftover concrete and fresh concrete with different ratios of Metakaolin powder and polypropylene fibers with the time duration of up to 5 hours. This time duration of returned concrete is taken into consideration for attaining desired compressive strength. So, each specimen for 1 hour leftover concrete, 2 hours leftover concrete, 3 hours leftover concrete, 4 hours leftover concrete and 5 hours leftover concrete are prepared and blended with fresh concrete with varying percentages of Metakaolin Powder and Polypropylene Fibers. The specimens were de-moulded after 24 hrs and tested for compressive strength after 28 days of curing as per IS 456:2000.

1. Returned concrete and fresh concrete mixing procedure:

In this stage, the fresh concrete with Metakaolin Powder and Polypropylene fibers is used and mixed with the returned concrete. This returned concrete we are using for the research work is 1 hour old, 2 hours old, 3 hours old, 4 hours old and five hours old with varying percentages of fresh concrete. For blending of fresh concrete with old concrete, we are varying the percent use of old concrete and new concrete. Three cubes of each blend with all

RESULTS AND DISCUSSIONS:

COMPRESSIVE STRENGTH TEST:

durations are taken into consideration and tested for the same.

- First specimen sample is, 90% fresh concrete is mixed with 10% returned concrete,
- The second specimen sample is of 80% fresh concrete mixed with 20% returned concrete,

Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder,
Polypropylene Fibers And Superplasticizers

- The third specimen sample is of 70% fresh concrete is mixed with 30% returned concrete,
- Then fourth specimen sample is of 60% fresh concrete is blended with 40% returned concrete and
- The fifth one specimen sample is of 50% fresh concrete blended with 50% returned concrete. Similarly, we are blending this way for 2 hours old concrete, 3 hours old concrete, 4 hours old concrete and 5 hours old concrete.

- Also, for each time duration and each varying percentage of this blend, we are varying the dosage of Metakaolin powder and Polypropylene fibers. The metakaolin powder dosage is varying from 5%, 10% and 15% and the Polypropylene fiber dosage is from 0.25%, 0.50% and 0.75%. The added retarding plasticizers are also varying from 1%, 2% and 3%. Three cubes of each blend with all durations are taken into consideration and tested for the same.

Sr. No.	Percentage of Concrete (%)		Materials Used (%)			Mix No.	CST Values for given RC Timeline(Hours) in MPa						
	Fresh	Old	MK Powder	PP Fibers	SP		0	1	2	3	4	5	
1	100	0	0	0	0	C1	31.6	31.6	31.6	31.6	31.6	31.6	
			5	0	0	C2	32.9	32.9	32.9	32.9	32.9	32.9	
			10	0	0	C3	35.7	35.7	35.7	35.7	35.7	35.7	
			15	0	0	C4	38.3	38.3	38.3	38.3	38.3	38.3	
			20	0	0	C5	31.3	31.3	31.3	31.3	31.3	31.3	
				5	0.25	0	C6	32.2	32.2	32.2	32.2	32.2	32.2
				10	0.25	0	C7	33.3	33.3	33.3	33.3	33.3	33.3
				15	0.25	0	C8	36.7	36.7	36.7	36.7	36.7	36.7
				20	0.25	0	C9	30.8	30.8	30.8	30.8	30.8	30.8
				5	0.5	0	C10	31.8	31.8	31.8	31.8	31.8	31.8
				10	0.5	0	C11	32.2	32.2	32.2	32.2	32.2	32.2
				15	0.5	0	C12	34.9	34.9	34.9	34.9	34.9	34.9
				20	0.5	0	C13	30.4	30.4	30.4	30.4	30.4	30.4
				5	0.75	0	C14	31.1	31.1	31.1	31.1	31.1	31.1
				10	0.75	0	C15	31.6	31.6	31.6	31.6	31.6	31.6
				15	0.75	0	C16	33.8	33.8	33.8	33.8	33.8	33.8
				20	0.75	0	C17	30.1	30.1	30.1	30.1	30.1	30.1
				5	0.25	1	C18	36.2	36.2	36.2	36.2	36.2	36.2
				10	0.25	1	C19	42.8	42.8	42.8	42.8	42.8	42.8
				15	0.25	1	C20	44.7	44.7	44.7	44.7	44.7	44.7
			20	0.25	1	C21	34.9	34.9	34.9	34.9	34.9	34.9	
			5	0.5	2	C22	38.1	38.1	38.1	38.1	38.1	38.1	
			10	0.5	2	C23	42.2	42.2	42.2	42.2	42.2	42.2	
			15	0.5	2	C24	44.8	44.8	44.8	44.8	44.8	44.8	
			20	0.5	2	C25	37.2	37.2	37.2	37.2	37.2	37.2	
			5	0.75	3	C26	36.2	36.2	36.2	36.2	36.2	36.2	
			10	0.75	3	C27	42.2	42.2	42.2	42.2	42.2	42.2	
			15	0.75	3	C28	47.2	47.2	47.2	47.2	47.2	47.2	
			20	0.75	3	C29	35.4	35.4	35.4	35.4	35.4	35.4	
			2	90	10	0	0	0	C1	31.6	31.75	31.7	31.65

Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder,
Polypropylene Fibers And Superplasticizers

			5	0	0	C2	32.9	33.05	33	32.95	32.9	32.85
			10	0	0	C3	35.7	35.85	35.8	35.75	35.7	35.65
			15	0	0	C4	38.3	38.45	38.4	38.35	38.3	38.25
			20	0	0	C5	31.3	31.45	31.4	31.35	31.3	31.25
			5	0.25	0	C6	32.2	32.05	32	31.95	31.9	31.85
			10	0.25	0	C7	33.3	33.15	33.1	33.05	33	32.95

Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder,
Polypropylene Fibers And Superplasticizers

			15	0.25	0	C8	36.7	36.55	36.5	36.45	36.4	36.35
			20	0.25	0	C9	30.8	30.65	30.6	30.55	30.5	30.45
			5	0.5	0	C10	31.8	31.64	31.59	31.54	31.49	31.44
			10	0.5	0	C11	32.2	32.04	31.99	31.94	31.89	31.84
			15	0.5	0	C12	34.9	34.74	34.69	34.64	34.59	34.54
			20	0.5	0	C13	30.4	30.24	30.19	30.14	30.09	30.04
			5	0.75	0	C14	31.1	30.93	30.88	30.83	30.78	30.73
			10	0.75	0	C15	31.6	31.43	31.38	31.33	31.28	31.23
			15	0.75	0	C16	33.8	33.63	33.58	33.53	33.48	33.43
			20	0.75	0	C17	30.1	29.93	29.88	29.83	29.78	29.73
			5	0.25	1	C18	36.2	36.25	36.2	36.15	36.1	36.05
			10	0.25	1	C19	42.8	42.85	42.8	42.75	42.7	42.65
			15	0.25	1	C20	44.7	44.75	44.7	44.65	44.6	44.55
			20	0.25	1	C21	34.9	34.95	34.9	34.85	34.8	34.75
			5	0.5	2	C22	38.1	38.18	38.13	38.08	38.03	37.98
			10	0.5	2	C23	42.2	42.28	42.23	42.18	42.13	42.08
			15	0.5	2	C24	44.8	44.88	44.83	44.78	44.73	44.68
			20	0.5	2	C25	37.2	37.28	37.23	37.18	37.13	37.08
			5	0.75	3	C26	36.2	36.32	36.27	36.22	36.17	36.12
			10	0.75	3	C27	42.2	42.32	42.27	42.22	42.17	42.12
			15	0.75	3	C28	47.2	47.32	47.27	47.22	47.17	47.12
			20	0.75	3	C29	35.4	35.52	35.47	35.42	35.37	35.32
3	80	20	0	0	0	C1	31.6	31.76	31.71	31.66	31.61	31.56
			5	0	0	C2	32.9	33.06	33.01	32.96	32.91	32.86
			10	0	0	C3	35.7	35.86	35.81	35.76	35.71	35.66
			15	0	0	C4	38.3	38.46	38.41	38.36	38.31	38.26
			20	0	0	C5	31.3	31.46	31.41	31.36	31.31	31.26
			5	0.25	0	C6	32.2	32.04	31.99	31.94	31.89	31.84
			10	0.25	0	C7	33.3	33.14	33.09	33.04	32.99	32.94
			15	0.25	0	C8	36.7	36.54	36.49	36.44	36.39	36.34
			20	0.25	0	C9	30.8	30.64	30.59	30.54	30.49	30.44
			5	0.5	0	C10	31.8	31.63	31.58	31.53	31.48	31.43
			10	0.5	0	C11	32.2	32.03	31.98	31.93	31.88	31.83
			15	0.5	0	C12	34.9	34.73	34.68	34.63	34.58	34.53
			20	0.5	0	C13	30.4	30.23	30.18	30.13	30.08	30.03
			5	0.75	0	C14	31.1	30.92	30.87	30.82	30.77	30.72
			10	0.75	0	C15	31.6	31.42	31.37	31.32	31.27	31.22
			15	0.75	0	C16	33.8	33.62	33.57	33.52	33.47	33.42

Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder, Polypropylene Fibers And Superplasticizers

			20	0.75	0	C17	30.1	29.92	29.87	29.82	29.77	29.72
			5	0.25	1	C18	36.2	36.27	36.22	36.17	36.12	36.07
			10	0.25	1	C19	42.8	42.87	42.82	42.77	42.72	42.67
			15	0.25	1	C20	44.7	44.77	44.72	44.67	44.62	44.57
			20	0.25	1	C21	34.9	34.97	34.92	34.87	34.82	34.77
			5	0.5	2	C22	38.1	38.2	38.15	38.1	38.05	38
			10	0.5	2	C23	42.2	42.3	42.25	42.2	42.15	42.1
			15	0.5	2	C24	44.8	44.9	44.85	44.8	44.75	44.7
			20	0.5	2	C25	37.2	37.3	37.25	37.2	37.15	37.1
			5	0.75	3	C26	36.2	36.34	36.29	36.24	36.19	36.14
			10	0.75	3	C27	42.2	42.34	42.29	42.24	42.19	42.14
			15	0.75	3	C28	47.2	47.34	47.29	47.24	47.19	47.14
			20	0.75	3	C29	35.4	35.54	35.49	35.44	35.39	35.34
4	70	30	0	0	0	C1	31.6	31.77	31.67	31.62	31.57	31.52
			5	0	0	C2	32.9	33.06	32.96	32.86	32.76	32.66
			10	0	0	C3	35.7	35.86	35.76	35.66	35.56	35.46
			15	0	0	C4	38.3	38.46	38.36	38.26	38.16	38.06
			20	0	0	C5	31.3	31.46	31.36	31.26	31.16	31.06
			5	0.25	0	C6	32.2	32.04	31.94	31.84	31.74	31.64
			10	0.25	0	C7	33.3	33.14	33.04	32.94	32.84	32.74
			15	0.25	0	C8	36.7	36.54	36.44	36.34	36.24	36.14
			20	0.25	0	C9	30.8	30.64	30.54	30.44	30.34	30.24
			5	0.5	0	C10	31.8	31.63	31.53	31.43	31.33	31.23
			10	0.5	0	C11	32.2	32.03	31.93	31.83	31.73	31.63
			15	0.5	0	C12	34.9	34.73	34.63	34.53	34.43	34.33
			20	0.5	0	C13	30.4	30.23	30.13	30.03	29.93	29.83
			5	0.75	0	C14	31.1	30.92	30.82	30.72	30.62	30.52
			10	0.75	0	C15	31.6	31.42	31.32	31.22	31.12	31.02
			15	0.75	0	C16	33.8	33.62	33.52	33.42	33.32	33.22
			20	0.75	0	C17	30.1	29.92	29.82	29.72	29.62	29.52
			5	0.25	1	C18	36.2	36.27	36.17	36.07	35.97	35.87
			10	0.25	1	C19	42.8	42.87	42.77	42.67	42.57	42.47
			15	0.25	1	C20	44.7	44.77	44.67	44.57	44.47	44.37
			20	0.25	1	C21	34.9	34.97	34.87	34.77	34.67	34.57
			5	0.5	2	C22	38.1	38.2	38.1	38	37.9	37.8
			10	0.5	2	C23	42.2	42.3	42.2	42.1	42	41.9
			15	0.5	2	C24	44.8	44.9	44.8	44.7	44.6	44.5
			20	0.5	2	C25	37.2	37.3	37.2	37.1	37	36.9

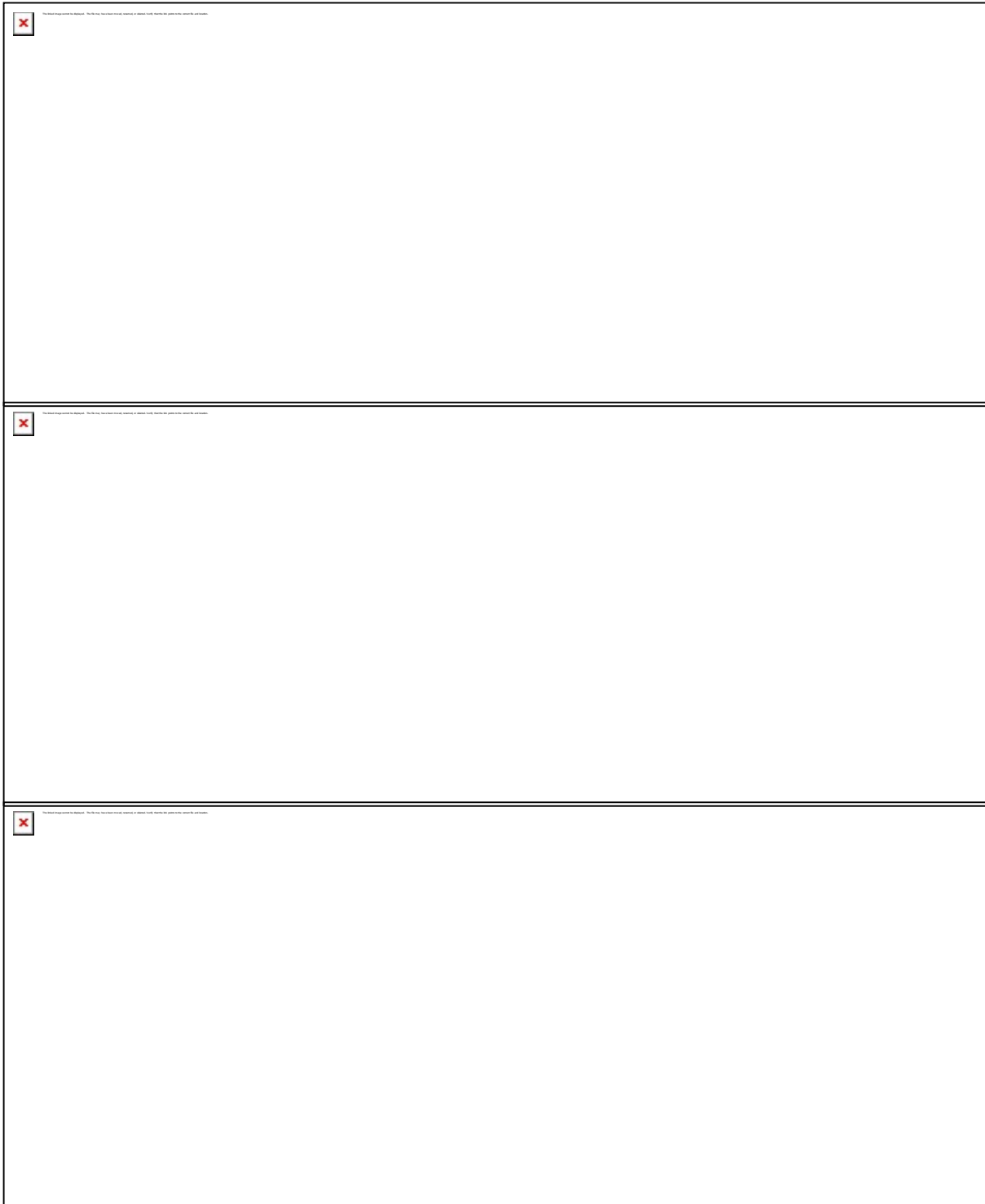
Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder, Polypropylene Fibers And Superplasticizers

			5	0.75	3	C26	36.2	36.34	36.24	36.14	36.04	35.94
			10	0.75	3	C27	42.2	42.34	42.24	42.14	42.04	41.94
			15	0.75	3	C28	47.2	47.34	47.24	47.14	47.04	46.94
			20	0.75	3	C29	35.4	35.54	35.44	35.34	35.24	35.14
5	60	40	0	0	0	C1	31.6	31.75	31.65	31.6	31.55	31.5
			5	0	0	C2	32.9	33	32.85	32.7	32.55	32.4
			10	0	0	C3	35.7	35.8	35.65	35.5	35.35	35.2
			15	0	0	C4	38.3	38.4	38.25	38.1	37.95	37.8
			20	0	0	C5	31.3	31.4	31.25	31.1	30.95	30.8
			5	0.25	0	C6	32.2	32.1	31.95	31.8	31.65	31.5
			10	0.25	0	C7	33.3	33.2	33.05	32.9	32.75	32.6
			15	0.25	0	C8	36.7	36.6	36.45	36.3	36.15	36
			20	0.25	0	C9	30.8	30.7	30.55	30.4	30.25	30.1
			5	0.5	0	C10	31.8	31.7	31.55	31.4	31.25	31.1
			10	0.5	0	C11	32.2	32.1	31.95	31.8	31.65	31.5
			15	0.5	0	C12	34.9	34.8	34.65	34.5	34.35	34.2
			20	0.5	0	C13	30.4	30.3	30.15	30	29.85	29.7
			5	0.75	0	C14	31.1	31	30.85	30.7	30.55	30.4
			10	0.75	0	C15	31.6	31.5	31.35	31.2	31.05	30.9
			15	0.75	0	C16	33.8	33.7	33.55	33.4	33.25	33.1
			20	0.75	0	C17	30.1	30	29.85	29.7	29.55	29.4
			5	0.25	1	C18	36.2	36.25	36.1	35.95	35.8	35.65
			10	0.25	1	C19	42.8	42.85	42.7	42.55	42.4	42.25
			15	0.25	1	C20	44.7	44.75	44.6	44.45	44.3	44.15
			20	0.25	1	C21	34.9	34.95	34.8	34.65	34.5	34.35
			5	0.5	2	C22	38.1	38.17	38.02	37.87	37.72	37.57
			10	0.5	2	C23	42.2	42.27	42.12	41.97	41.82	41.67
			15	0.5	2	C24	44.8	44.87	44.72	44.57	44.42	44.27
			20	0.5	2	C25	37.2	37.27	37.12	36.97	36.82	36.67
			5	0.75	3	C26	36.2	36.3	36.15	36	35.85	35.7
			10	0.75	3	C27	42.2	42.3	42.15	42	41.85	41.7
			15	0.75	3	C28	47.2	47.3	47.15	47	46.85	46.7
			20	0.75	3	C29	35.4	35.5	35.35	35.2	35.05	34.9
6	50	50	0	0	0	C1	31.6	31.65	31.53	31.41	31.29	31.17
			5	0	0	C2	32.9	32.97	32.77	32.57	32.37	32.17
			10	0	0	C3	35.7	35.77	35.57	35.37	35.17	34.97
			15	0	0	C4	38.3	38.37	38.17	37.97	37.77	37.57
			20	0	0	C5	31.3	31.37	31.17	30.97	30.77	30.57

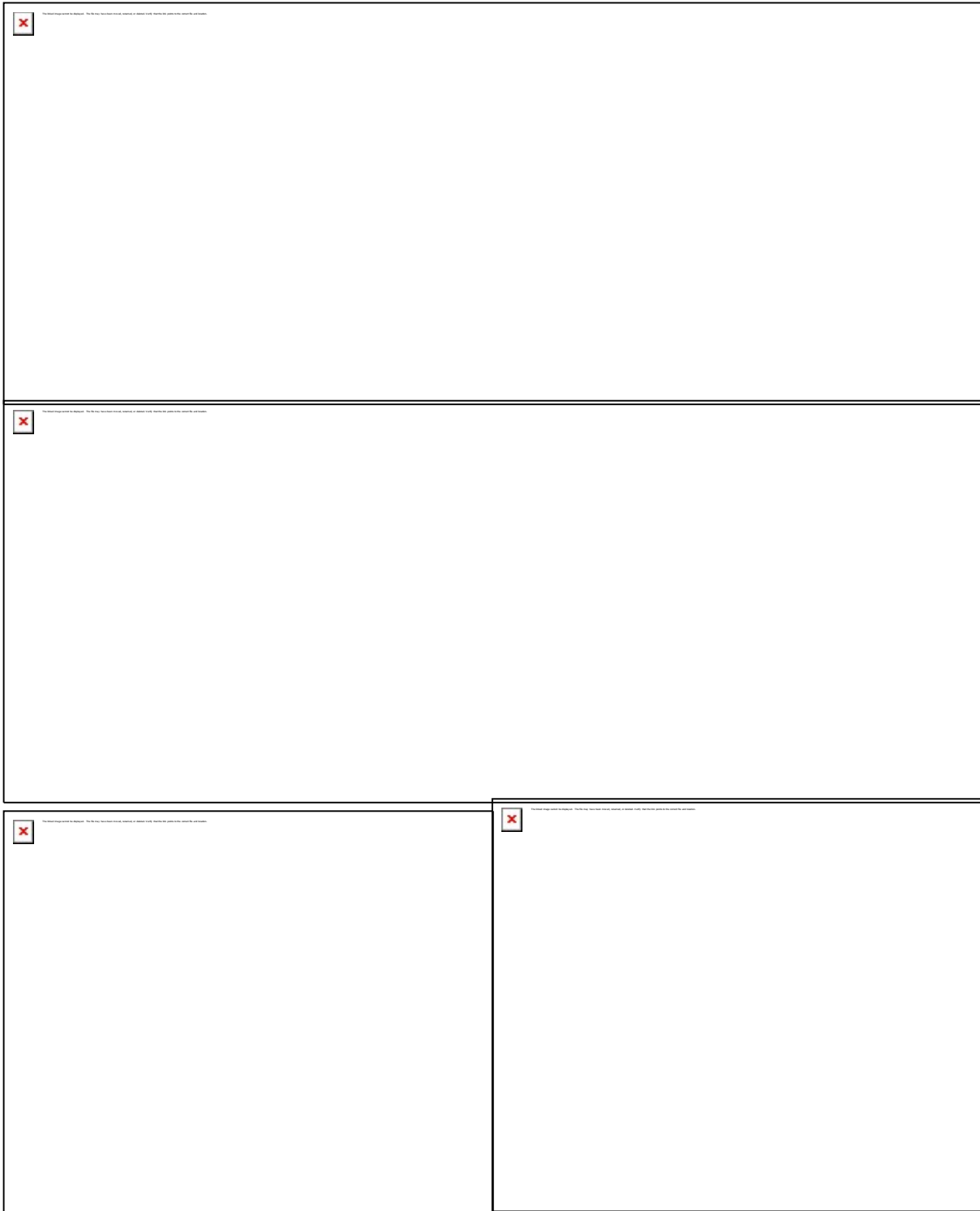
Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder,
Polypropylene Fibers And Superplasticizers

			5	0.25	0	C6	32.2	32.08	31.88	31.68	31.48	31.28
			10	0.25	0	C7	33.3	33.18	32.98	32.78	32.58	32.38
			15	0.25	0	C8	36.7	36.58	36.38	36.18	35.98	35.78
			20	0.25	0	C9	30.8	30.68	30.48	30.28	30.08	29.88
			5	0.5	0	C10	31.8	31.65	31.45	31.25	31.05	30.85
			10	0.5	0	C11	32.2	32.05	31.85	31.65	31.45	31.25
			15	0.5	0	C12	34.9	34.75	34.55	34.35	34.15	33.95
			20	0.5	0	C13	30.4	30.25	30.05	29.85	29.65	29.45
			5	0.75	0	C14	31.1	30.9	30.7	30.5	30.3	30.1
			10	0.75	0	C15	31.6	31.4	31.2	31	30.8	30.6
			15	0.75	0	C16	33.8	33.6	33.4	33.2	33	32.8
			20	0.75	0	C17	30.1	29.9	29.7	29.5	29.3	29.1
			5	0.25	1	C18	36.2	36.23	36.03	35.83	35.63	35.43
			10	0.25	1	C19	42.8	42.83	42.63	42.43	42.23	42.03
			15	0.25	1	C20	44.7	44.73	44.53	44.33	44.13	43.93
			20	0.25	1	C21	34.9	34.93	34.73	34.53	34.33	34.13
			5	0.5	2	C22	38.1	38.15	37.95	37.75	37.55	37.35
			10	0.5	2	C23	42.2	42.25	42.05	41.85	41.65	41.45
			15	0.5	2	C24	44.8	44.85	44.65	44.45	44.25	44.05
			20	0.5	2	C25	37.2	37.25	37.05	36.85	36.65	36.45
			5	0.75	3	C26	36.2	36.27	36.07	35.87	35.67	35.47
			10	0.75	3	C27	42.2	42.27	42.07	41.87	41.67	41.47
			15	0.75	3	C28	47.2	47.27	47.07	46.87	46.67	46.47
			20	0.75	3	C29	35.4	35.47	35.27	35.07	34.87	34.67

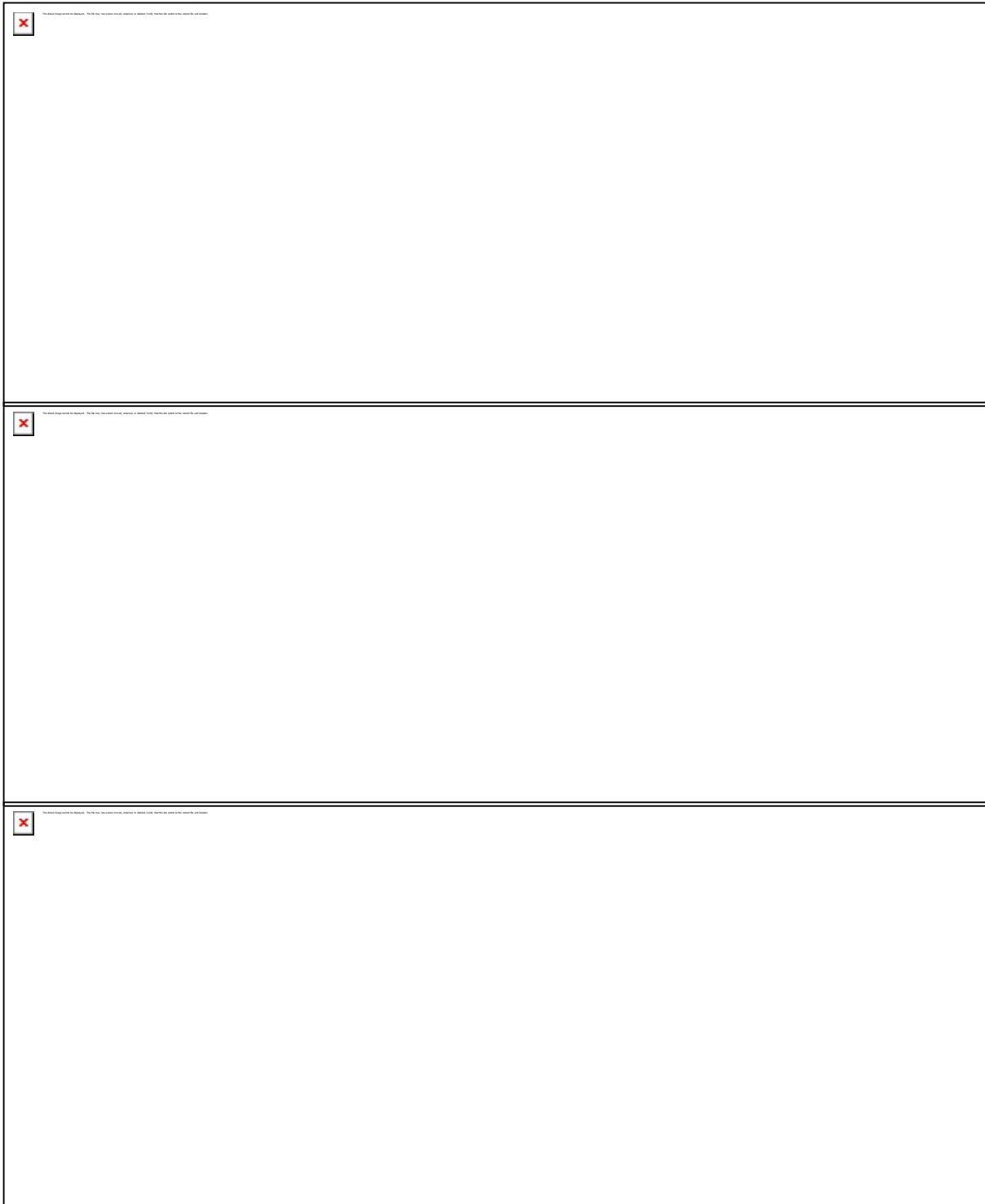
Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder,
Polypropylene Fibers And Superplasticizers



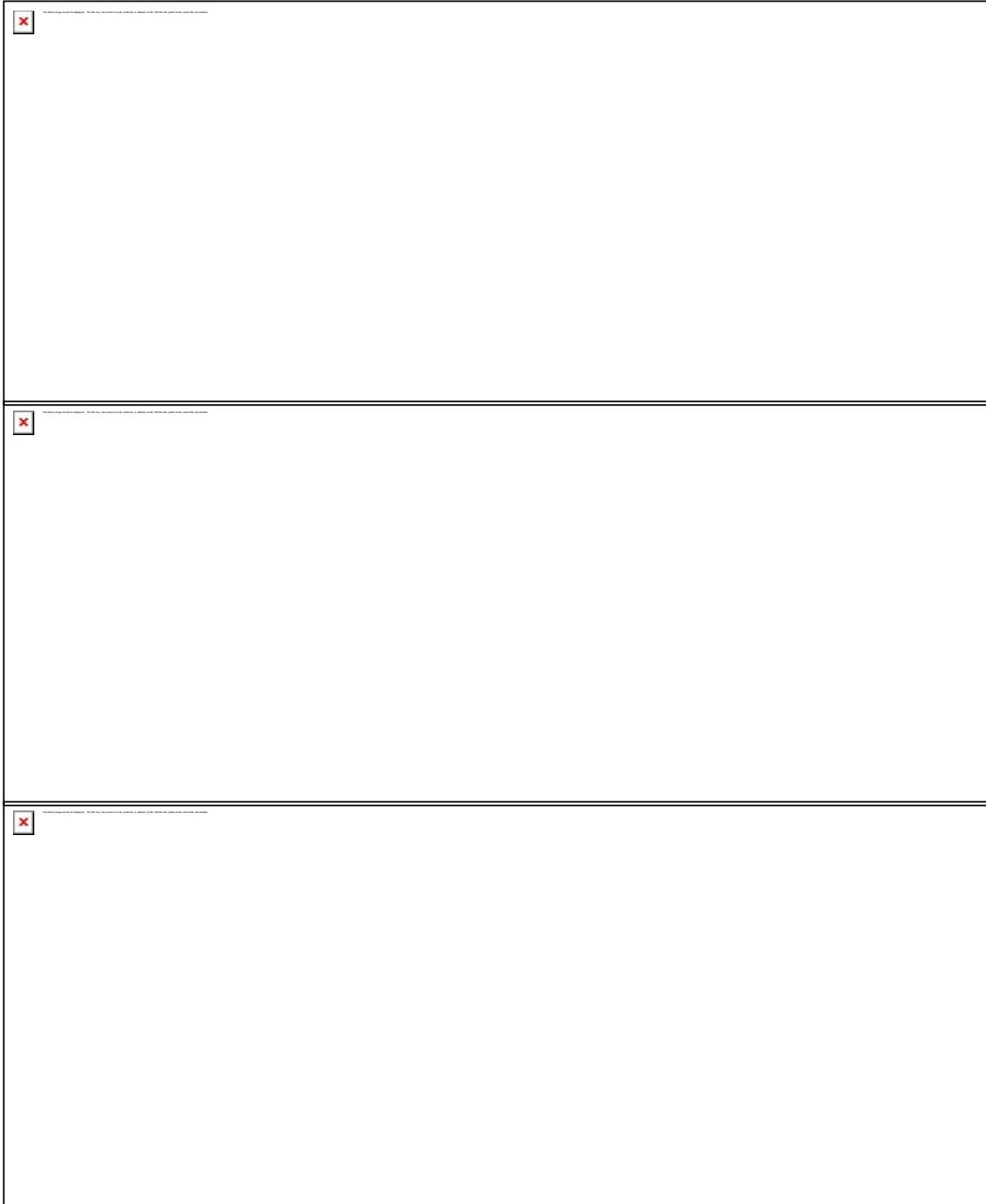
Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder, Polypropylene Fibers And Superplasticizers



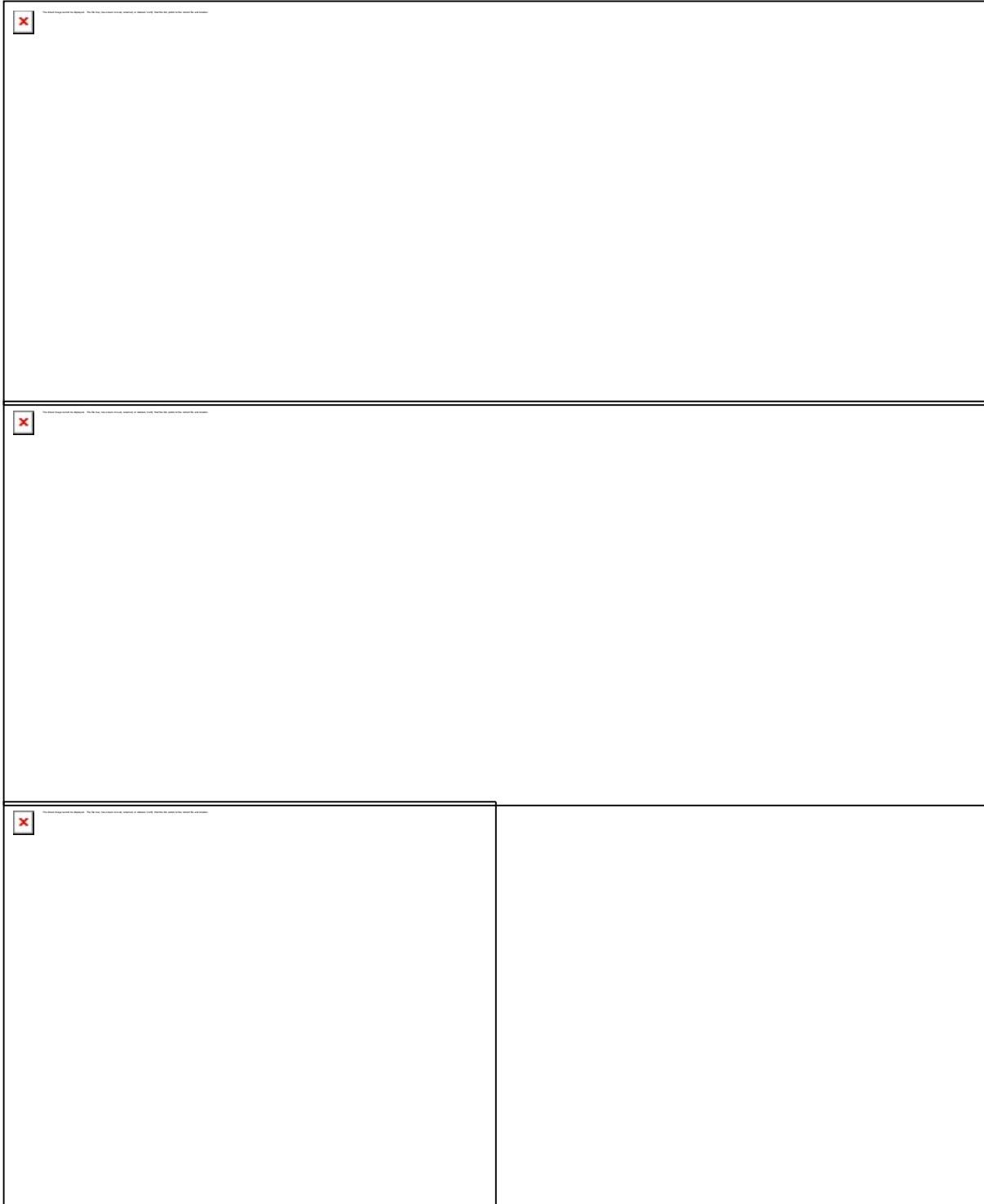
Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder,
Polypropylene Fibers And Superplasticizers



Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder, Polypropylene Fibers And Superplasticizers



Blending Of Returned Concrete With Fresh Concrete Incorporating Different Dosage Of Metakaolin Powder,
Polypropylene Fibers And Superplasticizers



As the ageing period increased from 0 hour to 5 hours, a gradual reduction in compressive strength was observed in mixes without admixture modification. This reduction is primarily due to the partial hydration of cement particles during the ageing period, which decreases the availability of active cement for further hydration after blending. For returned concrete aged up to 2 hours, the reduction in compressive strength was relatively small because sufficient

hydration potential remained within the cement matrix. However, for ageing periods of 3 to 5 hours, the loss of workability and increased stiffness of the returned concrete adversely affected compaction and resulted in lower compressive strength values.

Strength increased progressively with MK replacement from 5% to 15%, after which a slight reduction was observed at 20% replacement. The increase in compressive strength can be attributed due to the

pozzolanic reaction between metakaolin and calcium hydroxide released during cement hydration. This reaction produces additional calcium silicate hydrate (C-S-H) gel, which enhances the density and strength of the concrete matrix. Furthermore, the ultrafine particles of metakaolin improve particle packing and reduce capillary porosity. As fibre dosage increased from 0.25% to 0.50%, a noticeable increase in compressive strength was observed. The fibres acted as crack arresters and improved stress distribution throughout the concrete. At higher fibre contents approaching 0.75%, the rate of strength improvement became smaller because excessive fibres may reduce workability and create difficulties in achieving uniform compaction. As the dosage of SP increased from 1% to 2%, compressive strength increased due to better dispersion of cement particles and improved hydration efficiency. At near 3%, strength gains tended to stabilize because excessive dosage primarily improved workability rather than contributing directly to strength development. The best performance was generally observed for mixtures containing: Metakaolin: 10%–15%, Polypropylene fibres: 0.50%–0.75% And Superplasticizer approximately 2%

6. CONCLUSION:

- The fresh concrete incorporates metakaolin (MK) powder (5%–20%), polypropylene (PP) fibers (0.25%–0.75%), and superplasticizers (1%–3%), while considering returned concrete ageing periods ranging from 0 to 5 hours. The results revealed that the workability of blended concrete decreased progressively with increasing ageing duration of returned concrete. However, the incorporation of superplasticizers effectively compensated for this loss and restored the required workability without increasing the water-cement ratio.
- The inclusion of metakaolin improved the overall performance of blended concrete by enhancing the pozzolanic reaction and generating additional calcium silicate hydrate gel. Replacement levels of 5%–15% produced the most favorable results by improving matrix densification, reducing porosity, and enhancing strength and durability characteristics. Higher replacement levels of 20% provided additional pore refinement but occasionally resulted in reduced workability and marginal strength. Polypropylene fibers improved the tensile and flexural behavior of concrete by controlling microcrack formation and propagation. Fiber dosages around 0.5% provided the most balanced performance of compressive strength. Compressive strength results demonstrated that the adverse effects of returned concrete ageing could be substantially mitigated through the combined use of MK, PP fibers, and superplasticizers. Concrete containing 5%–15% MK, 0.5% PP fibers, and approximately 2% superplasticizer consistently exhibited superior strength performance compared with other combinations. Strength reductions became more noticeable when the ageing duration exceeded 4

hours due to weaker bonding and reduced hydration compatibility between returned and fresh concrete.

Based on the overall performance of fresh and hardened concrete, the optimum mix was found to contain 5%–10% metakaolin, 0.5% polypropylene fibers, and approximately 2% superplasticizer, with returned concrete ageing limited to 0–2 hours. Under these conditions, the blended concrete achieved superior workability, strength, durability, and structural integrity.

REFERENCES

- [1] Shetty. M.S.(2004), “Concrete technology – Theory & Practice”, S. Chand &Company, New Delhi.
- [2] Ramachandran, V.S. (2000), “Concrete Admixture Hand Book”, Standard Publishers & Distributors, New Delhi.
- [3] Mostafa M. Keshta, Mohamed M. Yousry Elshikh, Ahmed M. Elkerany (2025), “Performance of concrete containing different ratios of metakaolin and magnetized water”, <https://doi.org/10.1016/j.nxsust.2025.100107>
- [4] Karthik Obla, Haejin Kim, Colin Lobo (2007), “Crushed Returned Concrete as Aggregates for New Concrete”,
- [5] Bhuriya Dayal Dinabhai¹, Prof. Hiral Apurva Dave², Prof. Dr. Vijay Kumar B. Gadhvi (2025), “Effect of PET Fiber Geometry and Copper Slag on the Mechanical Properties and Durability of Concrete”, IJSAT25024181, Volume16, Issue2, April-June 2025
- [1] Reza Noroozi^a, Gholamali Shafabakhsh^a, Ali Kheyroddin^a, Abolfazl Mohammadzadeh Moghaddam (2019), “Investigating the effects of recycled PET particles, shredded recycled steel fibers and Metakaolin powder on the properties of RCCP”, DOI: <https://doi.org/10.1016/j.conbuildmat.2019.07.012>
- [2] Mohammad Malekipour^a, Faramarz Moodi (2021), “A novel approach to improve quality of delivered concrete using slump estimations of the ready-mixed concrete (RMC) truck mixer”, <https://doi.org/10.1016/j.job.2021.103361>
- [3] Negasi N. Gebremichael, S. Mahmoud Motahari Karein, Moses Karakouzian, Kazem Jadidi (2019), “Investigation of setting time and compressive strength of ready-mixed concrete blended with returned fresh concrete”, <https://doi.org/10.1016/j.conbuildmat.2018.11.201>.
- [4] Yuvaraj Dhandapani, Kirthika Kala Subramanian, Fragkoulis Kanavaris, Leon Black, Susan A. Bernal (2025), “The metakaolin content of the calcined clay source impacts the mechanical and durability performance of blended Portland concrete”, DOI:

<https://doi.org/10.1016/j.cemconres.2025.107922>

- [5] Ahmed Mohamed Abbass¹, Raed Firdous², Jean Noel Yankwa Djobo¹, Dietmar Stephan, Mohamed Abdelrahman (2023), “The role of chemistry and fineness of metakaolin on the fresh properties and heat resistance of blended fly ash-based geopolymer”, | <https://doi.org/10.1007/s42452-023-05359-y>
- [6] Mr. Rohit N.Gaidhane, Mr. Rohit Khadgi, Mr.Shubham Naukarkar, Mr. Nilesh Jangid, “Effect of Elevated Temperature on Conventional Concrete by Replacing Cement Partially with Metakaolin” IJSRD-International Journal for Scientific Research & Development| Vol.5, Issue01, 2017| ISSN(online):2321-0613
- [7] IS 456:2000 Plain and Reinforced Concrete - Code of Practice
- [8] IS 10262:2019 Concrete Mix Proportioning — Guidelines
- [9] IS 12269:2013 Ordinary Portland Cement 53 grade- Specifications
- [10] IS 383: Coarse and Fine Aggregate for Concrete –Specification
- [11] IS 2386-1963: Methods of Test for Aggregates for Concrete, Part I: Particle Size and Shape
- [12] IS 2386-1963: Methods of test for aggregates for concrete, Part 3: Specific gravity, density, voids, absorption and bulking.
- [13] IS 2386-4: Methods of test for aggregates for concrete, Part 4: Mechanical properties
- [14] IS 2386-5: Methods of Test for Aggregates for Concrete, Part V: Soundness
- [15] IS 16354 : 2015 : Metakaolin for Use in Cement, Cement Mortar and Concrete – Specification
- [16] IS 10951 : 2020: Specification for Polypropylene (PP) Materials for Moulding and Extrusion (Second Revision)
- [17] IS 9103:1999 Specification for Concrete Admixtures.